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# SUITABLE METHODOLOGY IN SUBJECTIVE VIDEO QUALITY ASSESSMENT: A RESOLUTION DEPENDENT PARADIGM

*Stéphane Péchard, Romuald Pépion, Patrick Le Callet*

Université de Nantes – IRCCyN laboratory – IVC team  
Polytech’Nantes, rue Christian Pauc, 44306 Nantes, France  
stephane.pechard@univ-nantes.fr

## ABSTRACT

Subjective video quality assessment provides a reliable and useful ground truth for the conception of objective quality metrics. This is a mature field with several standardized methodologies. Laboratories use these methodologies but rarely more than one. Selecting the methodology fitting experimental requirements and constraints is a difficult task. In this paper, two popular video quality assessment methodologies are compared. The authors used them for the quality assessment of HDTV, VGA and QVGA sequences. We show that the relation between both methodologies depends on the resolution. This result conducted to consider the precision of the results depending on the number of observers involved. We indicate how many observers are required to obtain the same precision with both methodologies.

## 1. INTRODUCTION

Subjective video quality assessment is an efficient way of obtaining reliable video quality measurements. These are then used to confront designed objective metrics to reality. Several methodologies are available, depending on the quantity to evaluate, the test conditions or the required precision [1, 2]. Such methodologies are time-consuming, long and expensive. It is essential to optimize the quantity and the precision of the obtained data for a given number of observers. We investigate the impact of the resolution on two assessment methodologies scores sets. The result conducted us to evaluate the methodologies precision depending on the number of observers used.

These days, two assessment methodologies are particularly popular in the industry. The first one is the Absolute Category Rating (ACR) methodology [3], notably used by the Video Quality Experts Group [4]. This is a category judgment where the test sequences are presented one at a time and are rated independently on a category scale. After each presentation, observers are asked to evaluate the quality of the sequence. The order of the test sequences is randomized such that each observer views the video clips

in a different order. Voting is not time-limited. The quality scale is made of five items, as depicted on the right side of Figure 1. Reference sequences are usually included in a test session, but are not identified by the observers. This methodology, well-known for its simplicity and efficiency, allows the assessment of a great number of sequences in a session. For example, in the context of VQEG’s work [4], 166 8-second-long sequences are assessed in an around 35-minute-long session. This efficiency is balanced by the precision, as ACR requires more observers than other methodologies. VQEG recommends to use groups of at least 24 observers.

The second methodology is the Subjective Assessment Methodology for Video Quality (SAMVIQ) [2]. This is a multiple stimuli assessment methodology using a continuous quality scale shown on the left side of Figure 1. Two reference sequences are used in a session. The first one is explicit, defined as the high quality anchor for the rest of the current presentation. The second one is hidden, randomly included amongst processed sequences. The observer is allowed to choose the viewing order of the sequences. He/she can modify notes and repeat viewings as he/she wants, but every sequence has to be assessed. Several contents, each processed several times, are assessed in a session. SAMVIQ is only able to assess 48 sequences in an around 35-minute-long session. However, the possibility to refine the judgment with multi-viewing allows to increase the measure precision and to decrease the number of observers. Thus, the EBU recommends to use at least 15 observers.

Three major differences between ACR and SAMVIQ have been identified. The first one is the type of scale. ACR uses a discrete scale while SAMVIQ uses a continuous scale. Corriveau [5] shown that this may imply a difference in the used quality ranges. Results from ACR are more likely to reach the scale limits. Corriveau explains this by the fact that in a categorical scale, there is no possible variations around best and worst qualities, while observers tend not to use the extreme scores of a continuous scale. The second difference is the number of viewing of each sequence. Sequences are viewed once in ACR, but as many times as

the observers want in SAMVIQ. The last difference is the eventual presence of the explicit reference. It is present in SAMVIQ but not in ACR. It modifies the task asked to the observer, as he/she has to construct his/her judgment against the explicit reference if it is available. It is a fidelity task. In ACR, the assessment is absolute. It is a quality task.

In this paper, we investigate the use of both ACR and SAMVIQ methodologies on HDTV, VGA and QVGA sequences. Results from both methodologies are compared and the impact of the resolution is evaluated. The second part of the paper is dedicated to the impact of the number of observers on the precision of the measure.

## 2. COMPARISON OF SUBJECTIVE SCORES

The HDTV set is made of 24 contents coded at 8 H.264 bitrates. 4 QVGA and 4 VGA contents have been coded at 4 H.264 bitrates and 2 SVC coding scenarios with different framerate and bitrate. These three sets were assessed with both ACR and SAMVIQ. Instructions of each test are minimal. They just inform observers about their task and the way they have to perform it.

### 2.1. Quality scale adjustment

In order to ease comparison between ACR and SAMVIQ data, the ACR scores were linearly mapped from 1-5 to SAMVIQ 0-100 scale. An original ACR score  $n$  is transformed in  $n'$  by:

$$n' = (n - 1) \times 20 + 10. \quad (1)$$

Therefore, 1 corresponds to 10 and 5 to 90. Effectively, on the SAMVIQ scale [2], the semantic terms are placed in the middle of the intervals as depicted on Figure 1. As a consequence, ACR has a shorter scale than SAMVIQ, with only 80% covered.

### 2.2. Comparison of ACR and SAMVIQ scores

Figure 2 shows ACR Mean Opinion Scores (MOS) as a function of SAMVIQ MOS for the HDTV sequences. MOS were computed from at least 24 validated observers for ACR and 15 for SAMVIQ. The linear correlation coefficient (CC) between both population is 0.8993, while the root mean square error is 14.06.

The linear correlation coefficient is not as much as we could anticipate. It is significantly lower to what has been observed at smaller resolutions [6, 7]. Brotherton [7] compared ACR and SAMVIQ methodologies on Common Intermediate Format (352×288) sequences. The CC between both sets of results equals 0.94. In this case, methodologies provide well related evaluations. In our case, both methodologies produce two data sets without a strong relation. No

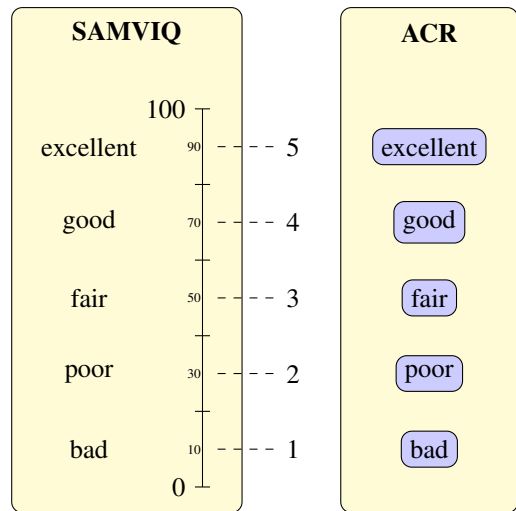


Fig. 1: Relation between ACR and SAMVIQ scales.

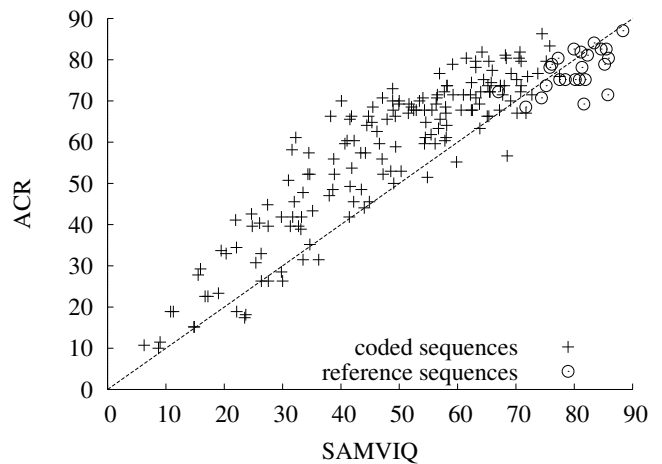


Fig. 2: ACR MOS as a function of SAMVIQ MOS for HDTV.

reliable model can be found to transform MOS from one methodology to the other. Even with the same purpose, these two methodologies do not provide superposable results.

The plot shows that ACR scores after transformation are greater to SAMVIQ scores, except at the extremities of the scale. ACR is then less critical than SAMVIQ, because distortions are better perceived with the latter. On the other hand, the inverse phenomenon is observed for reference scores, shown with circles. In this case, SAMVIQ scores are greater. What differences between methodologies can explain this?

First, the scale difference implies that ACR scores are limited to [10;90]. The results we obtained confirm Coriveau's trend [5]. With values between 10 and 87.04, ACR

uses 96.3% of the available range, while SAMVIQ uses only 82% with values from 6.27 and 88.33. However, reference sequences scores are far from upper limit in ACR. They are between 68.52 et 87.04, with a mean of 77.44. With a tendency to use the whole scale, this does not explain the observed phenomenon.

SAMVIQ allows an unlimited number of viewing. Observers can detect every distortions. Therefore, he/she tends to give a more precise score. In the case of a distorted sequence, this score is likely to be lower. On a reference sequence, several viewing do not help him to detect more distortions. Then, upper scores are used with SAMVIQ.

It is more difficult to draw a conclusion about the impact of the presence of the explicit reference. In SAMVIQ, the observer can not objectively see differences between both references. However, in a distortion context, he/she would not attribute a higher score than the explicit reference one. While comparing them, he/she only may assess them identically. Moreover, observers are not in the same psychological conditions while watching both references. The explicit one is clearly identified and is assessed as is. The hidden reference is a sequence as another and is assessed in comparison to the explicit one. It is then not obvious to attribute any impact to the presence of the explicit reference.

### 2.3. Impact of the resolution

Brotherton [7] shown that ACR and SAMVIQ provide correlated results for CIF sequences. It is not the case for the HDTV sequences we used. In order to confirm this trend, we conducted similar experiments with QVGA and VGA sequences. Table 1 sums up results obtained at several resolutions with the corresponding observation distance  $d$ , given as a multiple of the screen height  $H$ , and the visual field  $f$ , expressed in  $^\circ$ .

Format	Resolution	$d$	$f$	CC	RMSE
QVGA	320×240	6H	13	0,969	6.73
CIF	352×288	6H	12	0,94	×
VGA	640×480	4H	19	0,942	9.31
TVHD	1920×1080	3H	33	0,899	14.06

**Table 1:** Correlation coefficients and RMSE between ACR and SAMVIQ scores for several resolutions. CIF values are from [7]. The symbol × indicates that the value is not given by the author.  $f$  is expressed in  $^\circ$ .

The bigger the image, the lower the correlaton coefficient and the bigger the RMSE. Obviously, it is easier to obtain a higher correlation coefficient with fewer values and the HDTV correlaton coefficient is computed from 192 values, while the VGA and QVGA one only with 28. However, the trend allows to think that the resolution, and therefore

the visual field which takes in account the observation distance, would have a significant influence on CC between ACR and SAMVIQ MOS.

Here, the type of scale and the explicit reference presence have no influence. Only the number of viewing may imply such an impact. Effectively, with one or many viewing, a small image will still be assessed the same way. Reviewing it do not provide more information on its quality. On the other hand, a big image needs to be reviewed. The first visualisation is not sufficient to detect and assess all distortions. With SAMVIQ, the multiple viewing of a sequence allows to precise observer's judgement. Therefore, we can conclude that ACR and SAMVIQ are equivalent until a certain resolution. Beyond a certain threshold, both have unsimilar behaviors. It is an important piece of information for laboratories which want to implement such methodologies.

## 3. IMPACT OF THE NUMBER OF OBSERVERS ON ASSESSMENT PRECISION

Yet, we are not able to select the most suitable methodology between ACR and SAMVIQ only with the resolution of the image. Let's now discriminate both methodologies with the tradeoff between precision and number of observers. The precision of a MOS is measured by its 95% confidence interval. It depends on the number of observers involved in the computation of the MOS. ACR is known for its high number of observers and SAMVIQ for its precision.

### 3.1. Analysis method

We want to evaluate the impact of the number of observers on precision and how many observers are required in ACR to obtain the same precision as with SAMVIQ. However, each methodology uses its own rejection algorithm. This algorithm is destined to remove inconsistent observers' results. ACR uses ITU criterion, whereas SAMVIQ uses its own. Therefore, three modes of rejection are used :

1. without rejection ;
2. with ACR rejection (from ITU [1]) ;
3. with SAMVIQ rejection [2].

Table 2 presents the number of validated observers for each rejection mode and both methodologies. In the case of SAMVIQ, the first number indicates the maximal number of observers where all sequences are available. The second number indicates the maximal number of observers with available sequences.

The HDTV sequences database was assessed by 28 observers using ACR. SAMVIQ was used in three different sessions, therefore the number of observer is not the same in

methodology	mode 1	mode 2	mode 3
ACR	28	27	23
SAMVIQ	18-25	15-25	15-22

**Table 2:** Number of validated observers for each rejection mode and both methodologies. In the case of SAMVIQ, the first number indicates the maximal number of observers where all sequences are available. The second number indicates the maximal number of observers with available sequences.

each session. The analysis consists to compute confidence intervals for several number of observers  $N^P$ . For example, ACR confidence intervals are computed for  $N_{ACR}^P \in \{28, 25, 22, 20, 18, 15, 12, 10, 8\}$ . For each value of  $N_{ACR}^P$ , the  $C_{N_{ACR}}^{N_{ACR}^P}$  possible combinations are computed and we call mean confidence interval (MCI) for a given number of observers the mean of all these intervals. In our case,  $N_{ACR}^P = 28$ . For example :

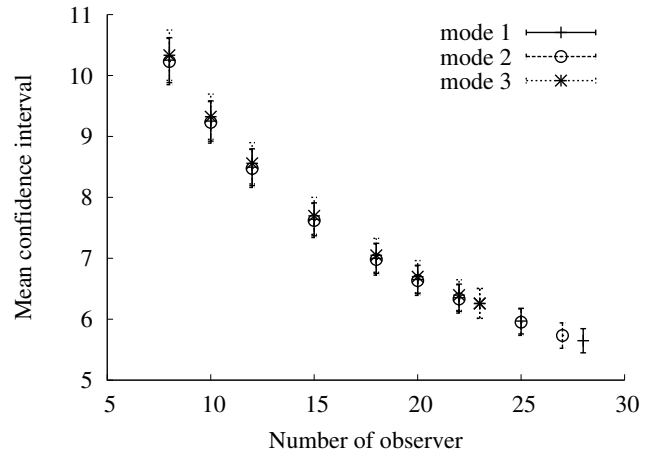
$$IC_{ACR}^8 = \frac{1}{C_{N_{ACR}}^8} \sum_{k=1}^{C_{N_{ACR}}^8} IC_{ACR}(k). \quad (2)$$

with  $N_{ACR}^P = 8$ . In the case of SAMVIQ, as the number of observers varies from a session to another, some means are computed with few observers. This increases the content dependency. Only means with at least 64 values are considered.

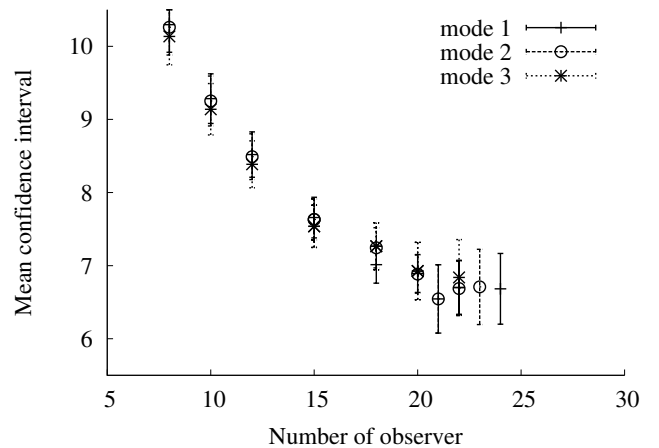
### 3.2. Mean confidence intervals as a function of number of observers

Figures 3 and 4 depict the mean confidence interval as a function of the number of observers involved in ACR and SAMVIQ tests respectively. Confidence intervals of the values are plotted as well. As expected, the MCI decreases as the number of observers increases. Differences between the three modes are insignificant. It means that the rejection criterion used has a very weak impact on the evaluation precision. Moreover, as ACR precision follows a very stable function, it is not the case for SAMVIQ with more than 15 observers. This is explained by the fact that the mean confidence interval is computed on a smaller number of video contents.

Obtained values seem to be very close between ACR and SAMVIQ. However, it does not take in account the fact that the ACR usable scale is shorter, as shown previously. It only represents 80% of SAMVIQ's scale. Nevertheless, a confidence interval equal to 10 on a 0-100 scale is more precise than the same on a 0-80 scale. In order to compare both sets of values, we adjusted intervals obtained by ACR to compensate scale differences. A factor of 1.25 is apply on ACR MCI.



**Fig. 3:** Mean confidence interval as a function of the number of observers involved in ACR tests for the three rejection modes.



**Fig. 4:** Mean confidence interval as a function of the number of observers involved in SAMVIQ tests for the three rejection modes.

Table 3 presents the mean confidence intervals obtained from ACR and SAMVIQ methodologies without any rejection algorithm. Both adjusted and not adjusted values are shown for ACR. As SAMVIQ values are not adjusted, only original values are in the table. The corresponding numbers of observers are in the table as well. We notice that after adjustment, all MCI from ACR are greater to SAMVIQ's. Moreover, the required number of observers for SAMVIQ is 15. At least 22 observers are required to obtain the same precision using the ACR methodology. This result indicates that with the same precision, SAMVIQ requires less observers. In compensation, each observer may assess a sequence several times.

Number of observers	MCI not adjusted		MCI adjusted
	ACR	SAMVIQ	ACR
8	10.252	10.296	12.815
10	9.253	9.284	11.567
12	8.495	8.519	10.619
15	7.640	7.658	9.550
18	6.999	7.014	8.749
20	6.652	6.893	8.315
22	6.352	6.701	7.940
25	5.969	5.964	7.461

**Table 3:** Mean confidence intervals (MCI) and corresponding number of observers for both ACR and SAMVIQ methodologies without rejection. Both adjusted and not adjusted values are shown for ACR.

### 3.3. Confidence interval of the mean confidence intervals

Tables 4 and 5 present the confidence intervals computed on the mean confidence intervals presented in the previous section. They globally decrease as a function of the number of observers. This trend is not verified in the case of the SAMVIQ methodology for more than 15 observers. This is explained by the fact that these values are computed with a lower number of sequences. The observed decrease shows that the precision on the mean confidence interval increases with the number of observers. This is simply because the dispersion between observers is more important with a lower number of observers.

The mode without rejection always provides confidence intervals lower than those provided with the two other rejection modes. Effectively, the total number of observers available for this computation is greater without rejection. Therefore with the same number of observers, the mean is computed with more confidence intervals than with the use of a rejection algorithm. The confidence interval on this mean is then lower. Nevertheless, differences between these

number of observers	mode 1	mode 2	mode 3
8	0,369	0,380	0,413
10	0,330	0,341	0,371
12	0,302	0,312	0,339
15	0,270	0,280	0,304
18	0,247	0,256	0,278
20	0,234	0,243	0,264
22	0,224	0,232	0,252

**Table 4:** Confidence intervals of mean confidence intervals from the ACR methodology for the three rejection modes.

number of observers	mode 1	mode 2	mode 3
8	0,377	0,380	0,389
10	0,339	0,341	0,351
12	0,310	0,313	0,321
15	0,278	0,280	0,289
18	0,254	0,275	0,321
20	0,259	0,261	0,393
22	0,369	0,372	0,518

**Table 5:** Confidence intervals of mean confidence intervals from the SAMVIQ methodology for the three rejection modes.

confidence intervals are not important.

In the same manner, confidence intervals given by the SAMVIQ rejection algorithm are greater than those given by the ACR rejection algorithm. The reason is the same, as the number of validated observers in SAMVIQ is lower than the number of validated observers in ACR as shown in Table 2.

## 4. CONCLUSION

This paper compared ACR and SAMVIQ subjective quality assessment methodologies. We first show that they have different behaviours, and that the relation between their results is weaker when the resolution increases. The resolution has an impact on this relation, as a bigger visual field represents more information to process. With its multi-viewing option, SAMVIQ is more accurate in considering such a quantity of information, while the unique view is not sufficient in ACR. We also stated that with a given number of observers, SAMVIQ is more precise than ACR. This latter requires more than 22 observers to get the same precision than SAMVIQ with only 15 observers. This result is very informative for assessment laboratories, in order to select the best methodology depending on the conditions of the tests they implement.

In the second part of the paper, we shown that the precision on methodologies precision measures also depends

on the number of observers involved. The more observers, the more precise are the confidence intervals. This result is consistent with the fact that using rejection algorithms imply a loss of precision, because less observers are involved. The same conclusion appears between ACR and SAMVIQ rejection algorithms, while ACR rejects less observers than SAMVIQ.

## 5. ACKNOWLEDGEMENT

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